DESIGN A NOVEL INHIBITOR FOR CORROSION PROTECTION IN OIL AND GAS ENVIRONMENTS

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ABSTRACT

This is a study on the designing and performance of corrosion inhibitor in oil and gas environments. The objective of this project is to determine the right composition of a corrosion inhibitor that can be used as corrosion protection in oil and gas environments. A suitable parameter to imitate the oil and gas environment used as guideline in this project which is a solution of 30% NaCl, room temperature, carbon steel as the experiment specimen. The data analyzed by using LPR (Linear Polarization Resistance) to determine the corrosion rate. the composition selected for the corrosion inhibitor is palm oil and amine. The minimum corrosion rate obtained from the experiment is 1.345 mmPY which is the combination of 2.0 ml palm oil and 3.0 ml of amine. Finally, by considering the result of each experiment that had been conducted, the composition of palm oil and amine can be used as a corrosion inhibitor.

ABSTRAK

Ini adalah satu kajian terhadap penciptaan dan prestasi inhibitor untuk menghalang proses pengaratan di dalam persekitaran industri minyak dan gas. Objektif projek ini adalah untuk menentukan komposisi yg paling sesuai yang boleh dijadikan inhibitor untuk mencegah dan melindungi daripada terjadinya proses pengaratan di dalam persekitaran industri minyak dan gas. Parameter yang sesuai berdasarkan persekitaran di dalam industry minyak dan gas dijadikan petunjuk utama dalam menjalankan eksperiment untuk kajian ini iaitu dengan menggunakan 30% kandungan NaCl, suhu bilik dan besi karbon sebagai spesimen untuk eksperimen. Data yang diproses dan dikaji adalah menggunakan LPR (Linear Polarization Resistance) untuk menentukan kadar pengaratan yang terjadi. Komposisi yang dipilih untuk dijadikan inhibitor bagi menghalang proses pengaratan ialah minyak kelapa sawit dan amine. Nilai kadar pengaratan yang paling minimum diperolehi daripada eksperimen yang dijalankan adalah 1.345 mmPY iaitu gabungan daripada komposisi 2.0 ml minyak kelapa sawit dan juga 3.0 ml amine. akhirnya, setelah mengambil kira dan mempertimbangkan keputusan bagi setiap eksperimen yang dijalankan, komposisi minyak kelapa sawit dan juga amine boleh digunakan sebagai inhibitor untuk mengelak daripada terjadinya proses pengaratan.

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LIST OF SYMBOLS

Rp	Polarization Resistance
CR	Corrosion Rate
LPR	Linear Polarization Resistance
Icorr	Corrosion Current
K	A constant that defines the units for the corrosion rate
EW	Equivalent Weight
ρ	Density
A	Sample area
βa	Anodic Beta Coefficient
βc	Cathodic Beta Coefficient

LIST OF ABBREVIATIONS

NaCl	Sodium Chloride
CO_2	Carbon Dioxide
Fe	Ferum
H	Hydrogen
H_2O	Hydrogen Oxide

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

This chapter explains about the background of study, problem statement, objectives and the scopes of this study. The main purpose for this study can be identified by referring at the problem statement of this study. Furthermore, the details of this study and outcome can be achieved on the objectives and its scopes.

1.2 BACKGROUND OF STUDY

Corrosion is a crucial and important problem faced in many sectors of industry. In oil and gas production, severe corrosion problems can arise when CO_2 is produced along with production fluids. One method to control significant metal losses occurring due to corrosion in the oil and gas industry is to use corrosion inhibitors.

Inhibitors are chemicals composition that will react with a metallic surface, and the environment this surface is exposed to, will give the surface a certain level of protection. Inhibitors usually work by adsorbing themselves on the metallic surface, and then will protect the metallic surface by forming such a film on it. Normally, inhibitors are distributed from dispersion or a solution. Some of it is included in a protective coating formulation. Inhibitors can help to slow down the corrosion processes by either:

- Increasing the anodic or cathodic polarization behaviour which can be seen from a Tafel slopes;
- Reducing the diffusion or the movement of ions to the metallic surface;
- Increasing the electrical resistance on the metallic surface.

1.3 PROBLEM STATEMENT

Corrosion can be easily interpreted as a deterioration of a metal or its own properties that will attacked every component in the life of every oil and gas field in every stage of it. Every stage of the oil and gas field means from the casing strings to production platforms, from drilling through to abandonment and so on. Basically, corrosion is totally an adversary worthy of all the high technology and research we can throw at it.

Because it is almost impossible to prevent corrosion, it is becoming more apparent that controlling the corrosion rate may be the most economical solution. Therefore, designing a novel inhibitor for corrosion protection in oil and gas environments is highly beneficial for the future of oil and gas industry.

1.4 OBJECTIVES

The main objective of this study is to design a novel inhibitor that can be used as a corrosion protection in oil and gas environments.

1.5 SCOPE

This project is based on experimental used test bench that available in the laboratory of University Malaysia Pahang as the main equipment. The Linear Polarization Resistance (LPR) technique will be used to measure the polarization resistance Rp and thus the corrosion rate could be determined. LPR measurements were conducted by plotting a curve of anodic and cathodic currents. Then to measure corrosion rate, it can use polarization resistance (Rp). Carbon steel will be used as the material in this project.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

This chapter will discusses about the previous related study and researches on fin. The source of the review is extracted from journals, articles, reference books and internet. The purpose of this section is to provide additional information and relevant facts based on past researches which related to this project. This chapter will cover the corresponding terms such as the fundamental of corrosion, its effect in oil and the efficiency of using inhibitor as corrosion protection in oil and gas industry.

2.2 CORROSION

As had been stated, corrosion can be seen as the deterioration of materials which is done by chemical interaction with the environment. The term corrosion itself sometimes can also be applied to the degradation of other materials such as plastics, concrete and wood, but generally we refer it to metals. The most widely used metal in the industry is iron which is usually referred as steel and the following discussion is mainly related to the corrosion process that happened on it.

As we all know, corrosion involves in the deterioration of a material when it reacts with the environment of the steel. Corrosion is the primary means which we can say that the metals deteriorate. Literally, corrosion consumes the material to reduce its load carrying capability and will cause stress concentrations to it. Moreover, corrosion is also often a major part of maintenance cost and the corrosion prevention is very vital in many designs that include steel as the material. Corrosion is not expressed in the terms of a design property value which is like any other properties. But it is rather in the more qualitative terms such as the material can be in an immune, resistant, susceptible or very susceptible condition to the corrosion process.

Corrosion process also involves in two chemical processes which is oxidation and also reduction. Basically, oxidation is the process of stripping electrons from an atom and the reduction process will occurs when an electron is added to an atom. These oxidation processes will take place at an area which is known as the anode. At the anode, the positively charged atoms will leave the solid surface and then will enter into an electrolyte as ions. The ions will then leave their corresponding negative charge in the form of electrons in the metal through a conductive path to travel to the location of the cathode.

Finally, at the cathode, the corresponding reduction reaction will then takes its place and consumes the free electrons. The electrical balance of the circuit can be restored at the cathode when the electrons react with neutralizing positive ions, such as the hydrogen ions in the electrolyte.

From this description, it can be clearly seen that there are basically four essential components that are needed for a corrosion reaction to proceed. These components are an anode, a cathode, an electrolyte with oxidizing species, and also some direct electrical connection which is between the anode and cathode.

The most common and also an important electrochemical reactions in the corrosion of iron are:

Anodic reaction (corrosion)

$$Fe \rightarrow Fe^{2+} + 2e$$

Cathodic reactions (simplified)

$$2H^{+} + 2e \rightarrow H2 \qquad (2a)$$

or

$$H_2O + \tfrac{1}{2} O_2 + 2e \rightarrow 2OH^{-} \qquad (2b)$$

The equation in reaction 2a is the most common reaction in acids and in the pH range 6.5 – 8.5. The most important reaction with oxygen can also be seen in the reduction equation in 2b. In this corrosion latter case, it is usually accompanied by the formation of solid corrosion debris from the reaction between the anodic and also cathodic products.

Although the atmospheric air is the most common environmental electrolyte, natural waters, such as seawater, as well as man-made solutions, the environments can also frequently associated with the corrosion problems.

2.2.1 Corrosion in Oil and Gas Industry

Corrosion problems have always presented such a severe challenge to the oil and gas producing operations. For that matter, operators need to plan for long periods of continuous production with the maintenance scheduled for the prescribed shutdown periods. Unfortunately, corrosion does not always respect these schedules that they made, which resulting in the severe economic penalties due to loss of product.

In addition to that, the risk of pollution and hazards to safety are other important reasons for adequate corrosion engineering. Governmental legislation concerning oil and gas extraction also had becoming more stringent in order to minimize these risks that we had been stated. Furthermore, corrosion hazards have also intensified with the extraction in deeper waters and in more hostile environments. The innovations aimed at reducing the offshore field development costs which involve the reductions in platform weight, increase the use of satellite wells and subsea manifolds require specific attention to corrosion prevention.

2.3 CORROSION INHIBITOR

It is well known that corrosion is a natural process and it is almost impossible to prevent it completely. Thus we can only try to control the corrosion process. Even though coatings and cathodic protection are often said as the most effective, chemical inhibitors are also widely used to reduce corrosion particularly in gas wells producing CO2, H2S and also water. But, the effectiveness of the inhibitor and compatibility with produced fluids must be first tested in the laboratory. The inhibitor film efficiency depends on the inhibitor concentration and its contact time with the metal surface.

One of the major ways in protecting the internal production pipelines in the field of operations against corrosion process is by applying corrosion inhibitors to it. The corrosion inhibitors are evaluated in order to make sure if the corrosion preventive measures applied are necessary and also to know if the required life-time can be achieved with the corrosion inhibitor as effective life of corrosion inhibitors varies with the quantity of water intrusion.

By definition, a corrosion inhibitor is a chemical compound or substance that, when we added it in such a small concentration to an environment, it will effectively decrease the corrosion rate. The efficiency of an inhibitor can be simply expressed by the measure of this improvement below:

Inhibitor efficiency (%) = 100 (CR uninhibited – CR inhibited) CR uninhibited

Where;

CR uninhibited = Corrosion rate of uninhibited

CR inhibited = Corrosion rate of inhibited

Generally, the efficiency of an inhibitor will increase together with an increase in inhibitors concentration. For example a typically good inhibitor would give 95% inhibition at a concentration of 0.008% and 90% at a concentration of 0.004%). More than that, the reliability of assessment of the effectiveness of gas flow lines protection by inhibition depends on the method employed on it. Assessment based on results received by several methods shows that it is possible to find a set of inhibitors that rate the most effective for each specific field and to develop the most optimal technology for their application. As a matter of fact, the effectiveness or the corrosion inhibitor efficiency, of a corrosion inhibitor is a function of many factors such as the fluid composition, flow regime condition, environment temperature, partial pressure of CO_2 and H_2S.

Gopal and Jepson (1995), defined that inhibitor react as a substance, that when it is added in a small concentrations, it will decrease the effect of corrosion rate. Corrosion inhibitors can fall into four general categories based on its mechanism and composition, these categories are;

i. Barrier Inhibitors

ii. Neutralizing Inhibitors

iii. Scavenging Inhibitors

2.4 COMPOSITION OF INHIBITOR

2.4.1 Palm Oil

They are many active green inhibitor intermediates present in the market that are using palm oil as one of their composition. Palm oil are widely used in the industry as corrosion inhibitor, however their properties and behaviour is such complex environment is far from being well known from scientific point of view.

The layer form on the metal surfaces will displace any water and form a monomolecular hydrophobic layer on the surface. The most effective system for this type of application would be a good solution for a metal. The protective coating is resistant to aqueous and asid corrosion.

Palm oil may be incorporated into lubricants for metal working, where it will function as an emulsifier and corrosion inhibitor. .

2.4.2 Amines

Amines contain nitrogen that are considered to be hard bases and so adsorb best to metal surfaces that are considered to be hard acids. Iron and steel are particularly well suited to being protected with amine-based corrosion inhibitors in acidic media. Generally amines with higher electron densities on their nitrogen atoms bind more strongly to metal surfaces and are more effective corrosion inhibitors. Cyclic amines are often better corrosion inhibitor than acyclic amines as ring strain eaves the nitrogen lone pair more exposed for donation. Also the presence of electron-donating groups on substituent aromatic rings helps to increase the electron density at the nitrogen bond angles that often perform best of all at corrosion inhibition.

CHAPTER 3

METHODOLOGY

3.1 INTRODUCTION

Several methods are selected to get the project done smoothly. The project must be done according to the objective and run effectively. The Gantt chart and flow chart are must have item in my methodology. The fuel cell needed to be sketched and the dimension are need to be precise so that right dimension can be selected for the bicycle and the design must be suitable for the bicycle so that it is not that over-estimate.

The study will be focused on designing a novel inhibitor for corrosion protection in oil and gas environments by using carbon steel as the material for experiments. The study also intends to determine the best inhibitor composition that can be used to decrease the corrosion rate of the carbon steel. In order to study the corrosion rate, LPR (Linear Polarization Resistance) are used. A detail of flow chart used to study in this work is shown in Figure 3.1.

3.2 FLOW CHART

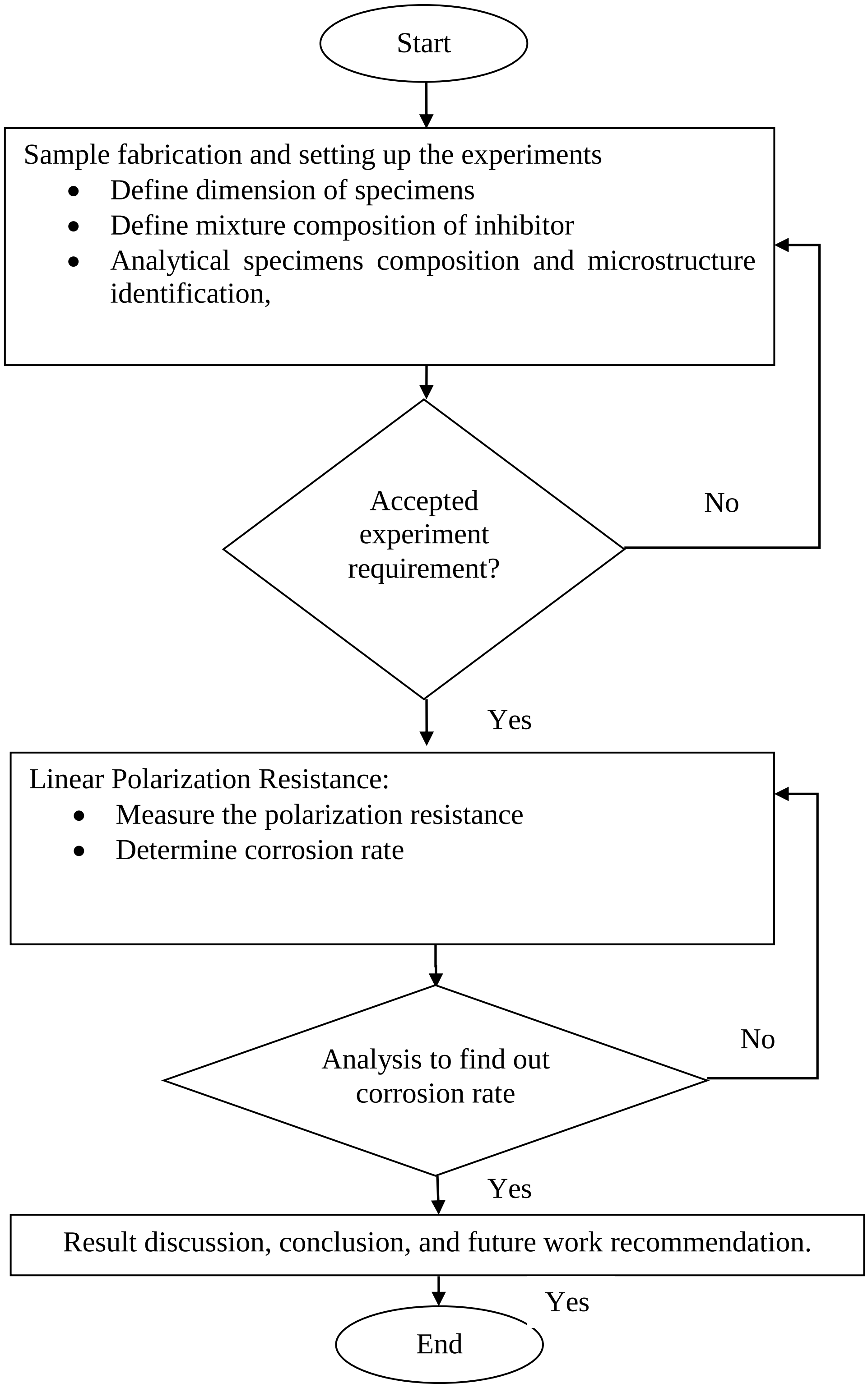
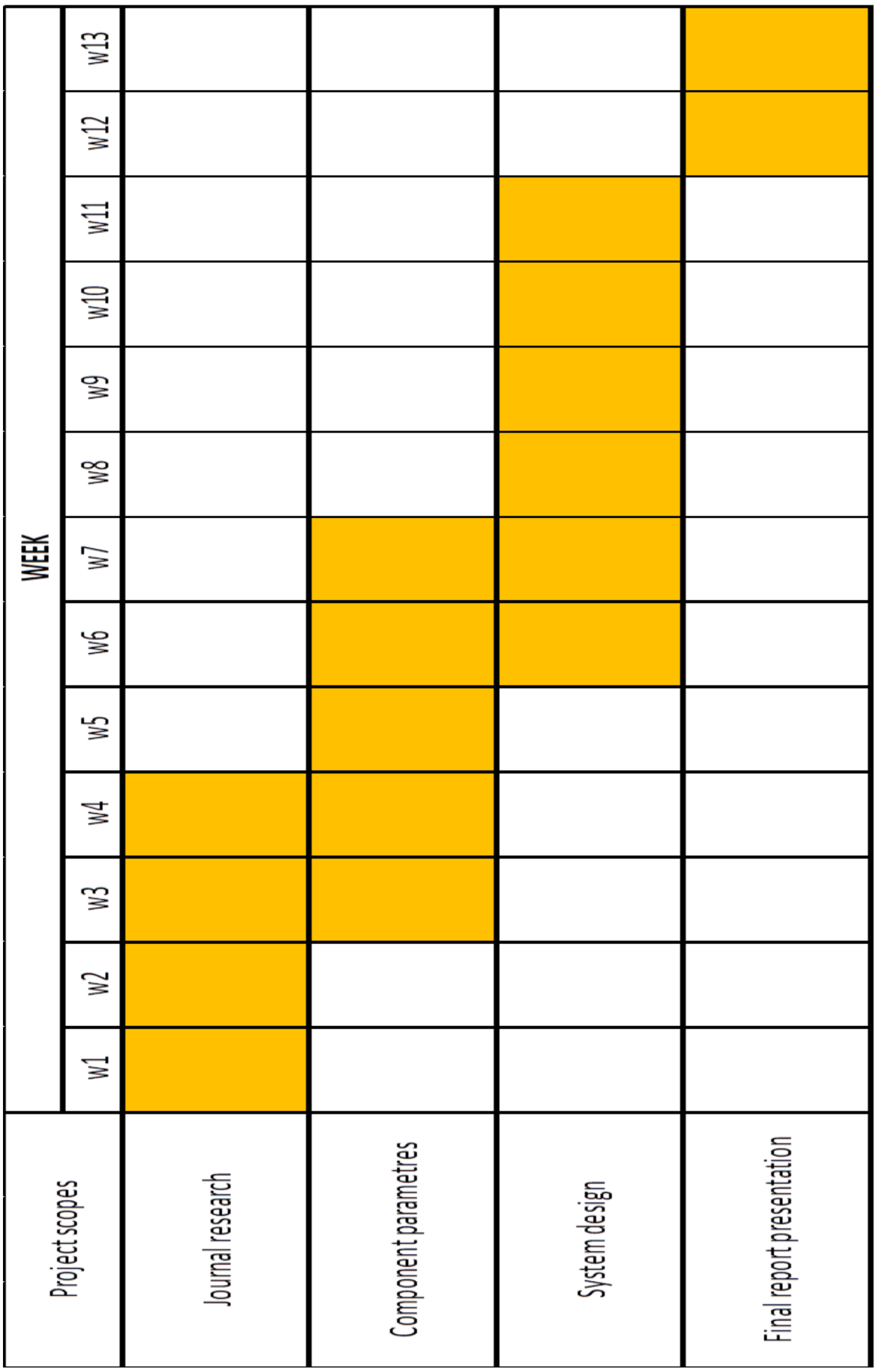


Figure 3.1: Experiment Flow Chart

3.3 GANNT CHART



3.4 EXPERIMENTAL PROCEDURE

3.4.1 Electrode

A three-electrode set-up was used in all electrochemical experiments. Carbon steel cylindrical was employed as the working electrode. Glass cell was fitted with graphite electrodes as an auxiliary electrode and a Ag/AgCl as a reference electrode.

3.4.2 Specimen Preparation

The working electrodes were carbon steels which have chemical compositions as can be seen in Table 1. It was a cylinder rod of 1.2 cm^2 in diameter and 1 cm thickness. Before immersion, the specimen surfaces were polished successively with 240, 400 and 600, 1200 grit SiC paper, rinsed with alcohol, and degreased using acetone.

Table 3.1: Steel 080A15 (BS 970) properties

Properties	Percentage (%)
C	0.148
Si	0.175
Mn	0.799
P	0.010
S	0.032
Cr	0.069
Mo	0.014
Ni	0.065